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U.S. DEPARTMENT OF COMMERCE, PATENT AND TRADEMARK OFFICE		DATE: March 29, 1999
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. PATENT NO. (If known) <b>09/269501</b>
INTERNATIONAL APPLICATION NO.: PCT/JP98/03411	INTERNATIONAL FILING DATE: July 30, 1998	PRIORITY DATE CLAIMED: July 30, 1997
TITLE OF INVENTION: LIQUID CRYSTAL DISPLAY DEVICE		
APPLICANT(S) FOR DO/EO/US: Yuichi AKIBA		
<p>Applicant hereby submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:</p> <ol style="list-style-type: none"> <li><input checked="" type="checkbox"/> This is a <b>FIRST</b> submission of items concerning a filing under 35 U.S.C. 371.</li> <li><input type="checkbox"/> This is a <b>SECOND</b> or <b>SUBSEQUENT</b> submission of items concerning a filing under 35 U.S.C. 371.</li> <li><input checked="" type="checkbox"/> This express request to begin national examination procedures (35 USC 371(f)) at any time rather than delay examination until the expiration of the time limit set in 35 USC 371(b) and PCT Articles 22 and 39(1).</li> <li><input type="checkbox"/> A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.</li> <li><input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2)): <ol style="list-style-type: none"> <li><input type="checkbox"/> is transmitted herewith (required only if not transmitted by the International Bureau).</li> <li><input checked="" type="checkbox"/> has been transmitted by the International Bureau.</li> <li><input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US)</li> </ol> </li> <li><input checked="" type="checkbox"/> A translation of the International Application into English (35 U.S.C. 371(c)(2)).</li> <li><input checked="" type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)) <ol style="list-style-type: none"> <li><input type="checkbox"/> are transmitted herewith (required only if not transmitted by the International Bureau).</li> <li><input type="checkbox"/> have been transmitted by the International Bureau.</li> <li><input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired.</li> <li><input checked="" type="checkbox"/> have not been made and will not be made.</li> </ol> </li> <li><input type="checkbox"/> A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).</li> <li><input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).</li> <li><input type="checkbox"/> A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).</li> </ol> <p><b>ITEMS 11. TO 16. BELOW CONCERN OTHER DOCUMENT(S) OR INFORMATION INCLUDED:</b></p> <ol style="list-style-type: none"> <li><input checked="" type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98 together with the international search report and 4 references.</li> <li><input checked="" type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.</li> <li><input checked="" type="checkbox"/> A <b>FIRST</b> preliminary amendment. <input type="checkbox"/> A <b>SECOND</b> or <b>SUBSEQUENT</b> preliminary amendment</li> <li><input type="checkbox"/> A substitute specification.</li> <li><input type="checkbox"/> A change of power of attorney and/or address letter.</li> <li><input checked="" type="checkbox"/> Other items or information: 9 sheets of drawings.</li> </ol>		

U.S. APPLICATION NO. (if known)	INTERNATIONAL APPLICATION NO. PCT/JP98/03411	DATE: March 29, 1999	
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17. <u>X</u> The following fees are submitted:  <b>Basic National Fee (37 CFR 1.492(a)(1)-(5)):</b> Search Report has been prepared by the EPO or JPO:.....\$840.00  International preliminary examination fee paid to USPTO (37 CFR 1.482).....\$670.00  No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)).....\$760.00  Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO..... \$970.00  International preliminary examination fee (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4).....\$ 96.00  <div style="text-align: right;">ENTER APPROPRIATE BASIC FEE AMOUNT =</div>	<b>CALCULATIONS</b>	<b>PTO USE ONLY</b>
\$ 840.00		

Surcharge of \$130.00 for furnishing the oath or declaration later than <u>20</u> <u>30</u> months from the earliest claimed priority date (37 CFR 1.492(e)).		
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CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
TOTAL	22 -20=	2	X \$ 18.00	\$ 36.00	
INDEPENDENT	1 - 3=		X \$ 78.00		
Multiple dependent claims(s) (if applicable)			+ \$260.00		
TOTAL OF ABOVE CALCULATIONS =				\$ 876.00	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).					
SUBTOTAL =				\$ 876.00	
Processing fee of \$130.00 for furnishing the English translation later than <u>20</u> <u>30</u> months from the earliest claimed priority date (37 CFR 1.492(f)).				+	
TOTAL NATIONAL FEE =				\$ 876.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31).				\$ 40.00	
TOTAL FEES ENCLOSED =				\$ 916.00	
				Amount to be: refunded	\$ _____
				charged	\$ _____

U.S. APPLICATION NO. (if known)	INTERNATIONAL APPLICATION NO. PCT/JP98/03411	DATE: March 29, 1999
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a. XX A check in the amount of \$916.00 to cover the above fees is enclosed.  
(This paper is filed in triplicate)


b.     Please charge my Deposit Account No. 01-2340 in the amount of \$        to cover the above fees.  
(A duplicate copy of this sheet is enclosed.)

c. X The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 01-2340.

**NOTE:** Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed to request that the application be restored to pending status.

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22,631  
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REGISTRATION NUMBER

WGK/yap

PATENT  
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Yuichi AKIBA

Serial Number: Not Yet Assigned

Filed: March 29, 1999

For: LIQUID CRYSTAL DISPLAY DEVICE

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents  
Washington, D.C. 20231

March 29, 1999

Sir:

Prior to the calculation of the filing fees of the above application, please amend the application as follows:

IN THE CLAIMS:

Claim 11, line 1, change "any one of Claims 1 to 10" to read --Claim 1--.

Claim 12, lines 1 and 2 change "any one of Claims 1 to 10" to read --Claim 1--.

Claim 13, line 1, change "any one of Claims 1 to 12" to read --Claim 1--.

Claim 17, lines 1 and 2 change "any one of Claims 1 to 12" to read --Claim 1--.

Claim 18, lines 1 and 2 change "any one of Claims 1 to 12" to read --Claim 1--.

Claim 19, lines 1 and 2 change "any one of Claims 1 to 18" to read --Claim 1--.

Claim 20, lines 1 and 2 change "any one of Claims 1 to 19" to read --Claim 1--.

Claim 21, lines 1 and 2 change "any one of Claims 1 to 19" to read --Claim 1--.

Claim 22, lines 1 and 2 change "any one of Claims 1 to 19" to read --Claim 1--.

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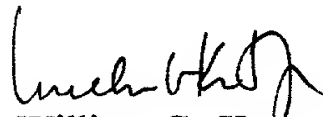
REMARKS

The above amendment is believed to remove the multiple dependency of the claims and place the claims in better condition for examination. Early and favorable action is awaited.

In the event there are any additional fees required, please charge our Deposit Account No. 01-2340.

Respectfully submitted,

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## DESCRIPTION

## LIQUID CRYSTAL DISPLAY DEVICE

## 5 TECHNICAL FIELD

The invention relates to a liquid crystal display device used as a display panel for a variety of electronic equipment such as a timepiece (watch and clock) and a portable information device.

## 10 BACKGROUND TECHNOLOGY

A timepiece for indicating digital display of time information such as hour, minute, and second, and calendar information such as date, days of the week, month, and year, by use of a liquid crystal display panel serving as a liquid crystal display device, has been in  
15 widespread use for wrist watches and clocks, provided with a crystal oscillation circuit.

There has also been in use a combination timepiece wherein an analog display indicating time information by the hands of the watch is used in combination with digital display indicating time information  
20 and calendar information in numbers and letters.

Further, there has been proposed an analog watch for selectively displaying markers in various patterns, or for displaying simulated hands for an hour hand, a minute hand, and a second hand, by making up the dial thereof based on a liquid crystal display panel  
25 (refer to, for example, Japanese Patent Laid-open S 54 - 153066).

In addition to a timepiece, in other electronic equipment such as a cellular phone, portable electronic calculator and portable game

machine, a reflection-type liquid crystal display device which is compact and demands extremely low power consumption is widely used as a display panel displaying required information (textual or image information).

5           In such a conventional liquid crystal display panel serving as a liquid crystal display device, a liquid crystal cell filled with liquid crystals is sandwiched between two transparent substrates each having an electrode on an inner facing surface thereof, and an upper polarizing film and a lower polarizing film are disposed, respectively,  
10   on the external opposite surface of each transparent substrate. If an electric field is applied to the liquid crystals by applying a voltage to the pair of electrodes on the transparent substrates holding the liquid crystal cell therebetween, the optical property of the liquid crystals is changed, thereby locally controlling transmission and absorption of  
15   light falling on the liquid crystal display panel such that a predetermined display is effected.

Each of the upper polarizing film and the lower polarizing film is a polarizing film absorbing the light linearly polarized in the direction orthogonal to the transmission axis thereof.

20           In the case of a watch using the conventional liquid crystal display panel described above, time information and calendar information are displayed in dark against a white background in the normally white mode that is common.

25           However, by simply displaying time information and calendar information in dark against the white background as described in the foregoing, neither variation in design nor fun of use can be offered, leading to rapid decline in product popularity among consumers.

Probably as a result, consumption of digital watches has recently been on the decline, and neither combination timepieces nor analog watches with liquid crystal display panels have received market acceptance.

As in the case of a timepiece, liquid display panels for other  
5 electronic equipment generally display various information in dark against the white background. Some can display in reverse, but these are still poor in variation in design and fun of use.

The invention has been developed in light of the present situation as described, and an object thereof is to provide a liquid  
10 crystal display device capable of displaying information brightly and clearly in an electronic equipment such as a timepiece and providing variation in design.

#### DISCLOSURE OF THE INVENTION

15 To this end, the invention provides a liquid crystal display device which is made up as follows.

An absorption-type polarizing film for absorbing the light linearly polarized in the direction orthogonal to the transmission axis thereof is disposed on the visible side of the liquid crystal cell, having  
20 a liquid crystal layer sealed in between a pair of transparent substrates, each having an electrode on the inner facing surfaces thereof, while a reflection-type polarizing film for reflecting the light linearly polarized in the direction orthogonal to the transmission axis thereof is disposed on the side of the liquid crystal cell opposite from the  
25 visible side thereof.

Further, a color filter is disposed on the visible side of the absorption-type polarizing film, or between the absorption-type



polarizing film and the reflection-type polarizing film.

Further, a light absorption film may be disposed on the side of the reflection-type polarizing film, opposite from the visible side thereof. Further, a light scattering film may be disposed on the visible side of the absorption-type polarizing film. Further, a backlight may be disposed on the side of the reflection-type polarizing film, opposite from the visible side thereof. In the latter case, a translucent film may be disposed between the reflection-type polarizing film and the backlight. An absorption-type polarizing film may be used as the translucent film.

In the liquid crystal display panel having the backlight disposed therein, a light scattering film may be disposed on the visible side of the absorption-type polarizing film.

In the aforementioned liquid crystal display panels, the absorption-type polarizing film is, preferably, disposed on the visible side of the liquid crystal cell such that the transmission axis of the absorption-type polarizing film is parallel with the direction of the long axes of liquid crystal molecules located on the visible side of the liquid crystal layer in the liquid crystal cell, while the reflection-type polarizing film is, preferably, disposed such that the transmission axis thereof is parallel with, or orthogonal to the direction of the long axes of liquid crystal molecules located on the side opposite from the visible side of the liquid crystal layer in the liquid crystal cell.

Alternatively, the absorption-type polarizing film is disposed on the visible side of the liquid crystal cell such that the transmission axis of the absorption-type polarizing film may be orthogonal to the direction of the long axes of liquid crystal molecules located on the

visible side of the liquid crystal layer in the liquid crystal cell while the reflection-type polarizing film is disposed such that the transmission axis thereof may be in parallel with, or orthogonal to the direction of the long axes of liquid crystal molecules located on the side opposite from the visible side of the liquid crystal layer in the liquid crystal cell.

(These conditions are particularly indicated when using a twisted nematic liquid crystal layer having a twist angle of  $90^\circ$  .)

As the color filter of the aforementioned liquid crystal display panel, it is preferable to use the following:

1) a selective transmission color filter for transmitting a light component substantially at a specified wavelength only;

2) a color polarizing film capable of transmitting a component of the light linearly polarized in the direction orthogonal to the transmission axis thereof, at a specified wavelength only, and absorbing light components of the linearly polarized at other wavelengths while transmitting all components of the light linearly polarized light in the direction parallel with the transmission axis thereof;

3) a dielectric multi layer film capable of reflecting a light component of incoming light having a specified wavelength, while transmitting light components of the incoming light at other wavelengths.

In the case of using a selective transmission color filter, selective transmission color filters in plural colors which transmit light components at different specified wavelengths can be arranged on the same plane.

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Additionally, selective transmission color filters in three colors at specified wavelengths of light components in red, green and blue are arranged in a given order repeatedly and regularly, so that multi-colored metallic color display by an additive color mixture is made possible.

Moreover, selective transmission color filters in three colors at specified wavelengths in the regions of wavelength of light components in cyan, magenta and yellow are arranged in a given order repeatedly and regularly, so that multi-colored metallic color display by a subtractive color mixture is also made possible.

The liquid crystal layer of said liquid crystal cell may be composed of any from among a twisted nematic liquid crystal layer, a supertwisted nematic liquid crystal layer, and a guest host liquid crystal layer.

The color filter of the liquid crystal display panel may be disposed between the absorption-type polarizing film and the liquid crystal cell or may be disposed between the liquid crystal cell and the reflection-type polarizing film. Alternately, the color filter may be disposed between the transparent substrates making up the liquid crystal cell and the liquid crystal layer.

In the liquid crystal display device according to the invention, light falling on the liquid crystal display panel from the visible side thereof is turned to linearly polarized light by the absorption-type polarizing film, and the linearly polarized light is either twisted or not twisted when transmitted through the liquid crystal cell of the liquid crystal display panel, depending on whether a voltage is applied or not between the electrodes in parts of the liquid crystal cell through which

the linearly polarized light is transmitted. If the light is linearly polarized in the direction parallel to the transmission axis of the reflection-type polarizing film upon reaching the reflection-type polarizing film, the linearly polarized light is transmitted through the reflection-type polarizing film. However, if the light is linearly polarized in the direction crossing the transmission axis of the reflection-type polarizing film at right angles upon reaching there, the linearly polarized light undergoes specular reflection by the reflection-type polarizing film, and is sent back to the visible side.

Further, since the color filter is disposed in the optical path of the linearly polarized light, the linearly polarized light is colored. Accordingly, parts where the linearly polarized light is reflected appear as a bright and colored display in a metallic tone or mirror-like tone, while parts where incoming light is transmitted through the reflection-type polarizing film are indicated in the color of the background of the parts (the colors of components inside the timepiece, or in black, white, or other optional colors in the case wherein the light absorption film, the translucent film, and so forth are installed). Accordingly, due to sharp contrast between these parts, time information and calendar information can be indicated in bright and colored display.

Thus, the invention can provide a liquid crystal display device for manufacturing a timepiece and other electronic equipment having variation in design.

Further, by disposing the light scattering film on the visible side of the absorption-type polarizing film of the liquid crystal display panel described above, light reflected through specular reflection by

the reflection-type polarizing film is scattered, turning colored display of a metallic tone or mirror-like tone to a more delicate tone of color so as to be seen with more ease while widening a viewing angle as well.

5        If the backlight is installed on the side of the reflection-type polarizing film opposite from the visible side, a half of light falling on the reflection-type polarizing film when the backlight is lit up is transmitted therethrough even in a dark environment such as at night, and is turned to linearly polarized light to fall on the liquid crystal cell.

10      There will be created parts where the linearly polarized light is twisted and parts where the linearly polarized light is not twisted depending on whether a voltage is applied between the electrodes of the liquid crystal cell or not, and as a result, time information and calendar information can be indicated distinctly in color display by a  
15      difference in brightness between parts where the linearly polarized light is transmitted through the absorption-type polarizing film and parts where the light linearly polarized is absorbed by the absorption-type polarizing film, and by coloring of the linearly polarized light by the agency of the color filter.

20

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic sectional view illustrating a construction of a first embodiment of a liquid crystal display device according to the present invention, and Figs. 2 and 3 are schematic sectional views  
25      illustrating respective modified examples;

Fig. 4 is a schematic sectional view of a liquid crystal cell incorporated therein as in Fig. 1 showing except a mid-portion, and

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Figs. 5-7 are sectional views illustrating respectively different examples of liquid crystal cells with a color filter incorporated therein and similar to Fig. 4;

Fig. 8 is a schematic sectional view illustrating the construction of the liquid crystal display device using the liquid crystal cell as shown in one of Figs. 5-7;

Figs. 9 and 10 are views for explaining the principles of colored display by the liquid crystal display device shown in Fig. 1;

Figs. 11-17 are schematic sectional views illustrating constructions of a second to eighth embodiments of the liquid crystal display device shown in Fig. 1;

Figs. 18 and 19 are views for explaining the construction of a ninth embodiment of the liquid crystal display device according to the present invention and the principles of colored display thereby;

Figs. 20 and 21 are views for explaining the construction of a tenth embodiment of the liquid crystal display device according to the present invention and the principles of colored display thereby;

## BEST MODE FOR CARRYING OUT THE INVENTION

A best mode for carrying out the invention will be now described with reference to the attached drawings.

### First Embodiment

First, a first embodiment of a liquid crystal display panel serving as a liquid crystal display device according to the present invention and a different example are described with reference to Figs. 1 to 10. These figures exaggerate the thickness of and spacing

between respective components.

Fig. 1 is a schematic sectional view illustrating the construction of the liquid crystal display panel 10, and Fig. 4 is a schematic sectional view of a liquid crystal cell 12 incorporated therein, in which a mid-portion is cutaway.

As shown in Fig. 1, the liquid crystal display panel 10 is made up of the liquid crystal cell 12, an absorption-type polarizing film 14 disposed on the visible side (the upper side in the figure) of the liquid crystal cell 12, a reflection-type polarizing film 16 disposed on the side opposite from the visible side (the underside in the figure) of the liquid crystal cell 12 and a color filter 18 disposed between the absorption-type polarizing film 14 and the liquid crystal cell 12.

As shown in Fig. 4, the liquid crystal cell 12 is made up by adhering together a pair of substrates 1, 2, made of transparent insulating material such as glass, with a sealant 4 disposed on the periphery thereof, so as to seal a liquid crystal layer 3 in a gap formed between the pair of the substrates to be interposed therebetween. Transparent electrodes 5, 6, made of indium tin oxide (ITO) and so forth, are formed on the inner faces of the pair of the substrates 1, 2, facing each other, respectively, and at least one of the electrodes is formed in such a pattern as is required for displaying time information and calendar information (for displaying numbers, generally, in the seven-segment display pattern).

The liquid crystal layer 3 is composed of twisted nematic (TN) liquid crystals having a twist angle of 90 degrees, and alignment treatment is applied to the surface of the respective substrates 1, 2 and the respective electrodes 5, 6, on the side in contact with the liquid

crystal layer 3, such that liquid crystal molecules are aligned in predetermined directions.

The absorption-type polarizing film 14 disposed on the visible side of the liquid crystal cell 12 is a sheet-shaped member for  
5 transmitting the light linearly polarized in the direction parallel with the transmission axis thereof, and absorbing the light linearly polarized in the direction orthogonal to the transmission axis thereof.

The reflection-type polarizing film 16 disposed on the side of the liquid crystal cell 12 opposite from the visible side is a sheet-  
10 shaped member for transmitting the light linearly polarized in the direction parallel with the transmission axis thereof, and reflecting the light linearly polarized in the direction orthogonal to the transmission axis thereof. As the reflection-type polarizing film 16, an optical film, for example, DBEF (trade name), manufactured by Sumitomo  
15 Three M Co., Ltd., is used.

The absorption-type polarizing film 14 is disposed such that the transmission axis thereof is parallel with the direction of the long axes of liquid crystal molecules located on the visible side of the liquid crystal layer 3 in the liquid crystal cell 12.

Also, the reflection-type polarizing film 16 is disposed such  
20 that the transmission axis thereof is parallel with the direction of the long axes of liquid crystal molecules located on the side opposite from the visible side of the liquid crystal layer 3 in the liquid crystal cell 12.

Consequently, the transmission axis of the absorption-type  
25 polarizing film 14 crosses that of the reflection-type polarizing film 16 at a right angle.



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In Fig. 1, the direction of stripes on the absorption-type polarizing film 14 and that of stripes on the reflection-type polarizing film 16 indicate the direction of the respective transmission axes, lateral stripes on the absorption-type polarizing film 14 indicating that  
5 the direction of the transmission axis thereof is parallel to the plane of the figure, while vertical stripes on the reflection-type polarizing film 16 indicating that the direction of the transmission axis thereof is perpendicular to the plane of the figure.

The color filter 18 disposed between the absorption-type  
10 polarizing film 14 and the liquid crystal cell 12 is a selective transmission color filter (also called an absorption-type filter) for transmitting a light component substantially at a specified wavelength only, and for absorbing light components at other wavelengths. Accordingly, light transmitted through this color filter is colored in a  
15 specified color.

For example, a pigment-dispersion coating film, prepared by dispersing a pigment in an organic resin and blending both together, is used for the selective transmission color filter. As the pigment-dispersion coating film can be formed by a coating method or a  
20 printing method, the same can be fabricated to a surface (for example, in Fig. 1, on the surface of the absorption-type polarizing film 14, opposite from the visible side, or in Fig. 6, on the outer surface of the substrate 1 disposed on the visible side of the liquid crystal cell 12) of one of the existing constituent members by means of the coating,  
25 without requiring any additional constituent member. Of light falling on the pigment-dispersion coating film, a light component at a specified wavelength only is transmitted therethrough, and light

components at other wavelengths are absorbed thereby.

Placement of the color filter 18 is not limited to the position shown in Fig. 1, and may be located anywhere on the visible side of the reflection-type polarizing film 16 which is composed of the liquid  
5 crystal display panel 10.

Accordingly, the color filter 18 may be disposed on the visible side (on the external side) of the absorption-type polarizing film 14 as shown in Fig. 2, or between the liquid crystal cell 12 and the reflection-type polarizing film 16 as shown in Fig. 3.

10 Otherwise, a liquid crystal cell 12CF with a color filter incorporated therein may be substituted for the liquid crystal cell 12 as shown in Fig. 5 or Fig. 6, and then, the liquid crystal display panel 10 can be made up simply by disposing the absorption-type polarizing film 14 and the reflection-type polarizing film 16, on the opposite  
15 sides of the liquid crystal cell 12CF, with the color filter incorporated therein as shown in Fig. 8.

In such a case, the color filter 18 may be formed by applying the pigment-dispersion coating film to the inner surface of the substrate 1 disposed on the visible side of the liquid crystal cell 12CF  
20 as shown in Fig. 5, or by applying the pigment-dispersion coating film to the inner surface of the substrate 2 disposed on the side of the liquid crystal cell 12CF opposite from the visible side as shown in Fig. 6.

The transparent electrode 5 or 6 is formed on the surface of the  
25 color filter 18 thus formed, in contact with the liquid crystal layer 3, however, the color filter 18 may be formed instead on the entire surface of the substrate 1 with the electrode 5 formed thereon, in

contact with the liquid crystal layer 3, or on the entire surface of the substrate 2 with the electrode 6 formed thereon, in contact with the liquid crystal layer 3.

In the case of using a selective transmission color filter as the color filter 18, selective transmission color filters in plural colors which transmit light components at a different specified wavelength can be arranged on the same plane.

Additionally, selective transmission color filters in three colors at specified wavelengths of light components in red, green and blue are arranged in a given order repeatedly and regularly, so that multi-colored metallic color display by an additive color mixture is made possible.

For instance, the liquid crystal 12CF with a color filter incorporated therein is composed as shown in Fig. 7, and a red pigment-dispersion coating film (R) at a specified wavelength of 600-700nm, a green pigment-dispersion coating film (G) at a specified wavelength of 500-600nm and a blue pigment-dispersion coating film (B) at a specified wavelength of 400-500nm, can be arranged on the inner surface of the substrate 1 as the color filter 18 so as to be in the order of R, G, B, repeatedly and regularly. An independent electrode element serving as the electrode 5 is formed on each of the pigment-dispersion coating films. The pigment-dispersion coating films R, G and B in three colors constitute one pixel, and ON/OFF of the voltage application between the electrode element on each pigment-dispersion coating film and the common electrode 6 opposite thereto is controlled, thereby an additive color mixture is achieved.

The example of providing the color filter 18 by the three-

colored pigment-dispersion coating films R, G and B on the inner surface of the substrate 1 on the visible side of the liquid crystal cell 12 is described above. However, it is needless to say that the color filter 18 can be provided on the inner surface of the substrate 2 opposite to the visible side. In such a case, the electrode 6 formed thereon is formed to be a electrode element corresponding to each of the pigment-dispersion coating films R, G and B, and the electrode 5 on the side of the substrate 1 is formed to be a common electrode.

The color filter 18 by the three-colored pigment-dispersion coating films R, G and B described above can be formed on the outer surface (the surface opposite to the liquid crystal layer 3) of either of the substrate 1 or 2. However, it is not favorable to form the color filter 18 as described above because when the pigment-dispersion coating films at a plurality of different specified wavelengths are arranged on the same plane, a subtractive color mixture is occurred relative to the incoming light from the slanting direction depending on the thickness of the substrate 1 or 2, thereby decreasing purity of color and brightness of the light.

Selective transmission color filters in three colors (cyan, magenta, yellow) which transmit light components at specified wavelengths in the regions of wavelength of cyan (400-600nm), magenta (400-500nm and 600-700nm) and yellow (500-700nm) can be arranged as the color filter 18 in a given order repeatedly and regularly. In such a case, multi-colored metallic color display by a subtractive color mixture is made possible.

Now, the principles of colored display by the liquid crystal display panel 10 shown in Fig. 1 are described with reference to Figs.

9 and 10.

In these figures, the lateral stripes on the absorption-type polarizing film 14 and the vertical stripes on the reflection-type polarizing film 16 indicate the direction of the respective transmission axes either parallel to the plane of the figure, or perpendicular to the plane of the figure as described with reference to Fig. 1. Longer solid lines with an arrow at one end thereof indicate the direction of light rays, and shorter solid lines with an arrow at opposite ends thereof indicate the direction of the light linearly polarized after the light rays pass through respective constituent members; ones shown oriented sideways being in the direction parallel to the plane of the figure, and ones shown oriented vertically being in the direction perpendicular to the plane of the figure.

As described in the foregoing, the liquid crystal layer 3 of the liquid crystal cell 12 is composed of the twisted nematic (TN) liquid crystals having the twist angle of 90 degrees, and the color filter 18 is the selective transmission color filter capable of transmitting a light component in yellow only, and absorbing light components in colors other than yellow.

Fig. 9 shows the background part when no voltage is applied between the electrodes 5 and 6 of the liquid crystal cell 12 (in an OFF state), where the direction of the light linearly polarized transmitted through the liquid crystal cell 12 is twisted by  $90^\circ$  (phase modulation) due to the twisting function of the liquid crystal layer 3 (Fig. 6).

Fig. 10 shows display parts for characters and so forth when a voltage is applied between the electrodes 5 and 6 of the liquid crystal cell 12 (in an ON state), where incoming linearly polarized light is

transmitted as it is through the liquid crystal cell 12 without the polarized direction thereof being twisted (phase modulation) as the liquid crystal layer 3 of the liquid crystal cell 12 loses the twisting function thereof with the liquid crystal molecules being set upright.

5           A half of light directed through the liquid crystal display panel 10 from the visible side (the upper side in the figure) is absorbed by the absorption-type polarizing film 14. The remaining half thereof is transmitted through the absorption-type polarizing film 14, and turned to the light linearly polarized in the direction parallel with the plane of  
10 the figure, falling then on the color filter 18.

Components of the linearly polarized light, in colors other than yellow, are all absorbed by the color filter 18 regardless of the ON/OFF state of the liquid crystal cell 12. A component of the linearly polarized light, in yellow, is transmitted through the color  
15 filter 18, falling on the liquid crystal cell 12.

With the liquid crystal cell 12 in the OFF state as shown in Fig. 9, the linearly polarized light in yellow falls on the reflection-type polarizing film 16 after the direction thereof is twisted by 90°, and oriented in the direction perpendicular to the plane of the figure while  
20 transmitted through the liquid crystal cell 12. Since the linearly polarized light in yellow is in the same direction as that of the transmission axis of the reflection-type polarizing film 16, same is transmitted through the reflection-type polarizing film 16, so that the background can be seen in dark (the colors of components inside a  
25 timepiece in the case of the liquid crystal display panel 10 being installed in the timepiece) from the visible side.

On the other hand, with the liquid crystal cell 12 in the ON

state as shown in Fig. 10, the linearly polarized light in yellow falls on the reflection-type polarizing film 16 with the polarized direction thereof remaining oriented in the direction parallel with the plane of the figure after being transmitted through the liquid crystal cell 12 without the direction thereof being twisted. Since the linearly polarized light in yellow has an oscillation direction oriented in the direction crossing the transmission axis of the reflection-type polarizing film 16 at a right angle, same undergoes specular reflection by the reflection-type polarizing film 16. As the reflected light of the linearly polarized light in yellow is sent back toward the visible side along the optical path in the direction reverse to that in which the linearly polarized light in yellow has come in, bright display in a yellow metallic tone can be indicated. Such display indicates a view in the same way as if a yellow color filter was placed on a mirror.

Accordingly, by applying a voltage between the electrodes of the liquid crystal cell 12 only in the display parts for characters for displaying information, bright display of characters can be indicated in a yellow metallic tone (similar to the color of gold) against the dark background, enabling the interior of a timepiece to be seen through.

Thus, with the liquid crystal display device according to the invention, substantially all light falling on the liquid crystal display panel 10, and colored, is reflected in regions for displaying information such as characters, enabling bright and colored display to be indicated in a metallic tone.

On the other hand, in the regions of the background for displaying information, light falling on the liquid crystal display panel 10 is transmitted through the reflection-type polarizing film 16, so

that the side of the reflection-type polarizing film 16, opposite from the visible side, can be seen through. As a result, display as a whole indicates characters and the like brought into relief in a colored and metallic tone.

5 Also, by disposing the reflection-type polarizing film 16 such that the transmission axis thereof crosses the direction of the long axes of the liquid crystal molecules on the side of the liquid crystal layer 3, opposite from the visible side, at a right angle, the transmission axis of the absorption-type polarizing film 14 is caused  
10 to be parallel with that of the reflection-type polarizing film 16, inverting the display condition described above by way of example, so that characters and so forth can be displayed in a fashion enabling the interior to be seen against the background in a yellow metallic tone.

If a color filter 18 capable of transmitting a light component in  
15 a different color is used, either the display parts or the background part can be indicated in display in the metallic tone of an optional color.

Accordingly, the invention can provide a liquid crystal display device having wide variation in design and offering some fun of use as  
20 well, in marked contrast to conventional liquid crystal display device for displaying various information in black against the background in white.

Also, for the liquid crystal display panel described above, a liquid crystal display panel of the dot matrix display mode may be  
25 adopted in order to display characters or graphics arbitrarily, or to display given graphics selectively by forming a electrode of a liquid crystal cell into many kinds of graphic patterns.



With any of the liquid crystal display panels wherein the color filter 18 is disposed in various positions as shown in Figs. 2, 3, and Figs. 5 to 8, respectively, the function of the respective liquid crystal display panels for colored display as described remains the same although a position where light falling on the liquid crystal display panel is colored by the color filter 18 is different in each case.

When the color filter 18 is constructed so that a pixel consists of three-colored pigment-dispersion coating films R, G and B as shown in Fig. 7, display by specular reflection light in which light components in three colors, i.e., red, green and blue, are given an additive color mixture per pixel can be achieved, thereby enabling color display of arbitrary characters or graphics in multi-colored metallic tone.

A case where the liquid crystal layer 3 sealed in the liquid crystal cell 12 is composed of the twisted nematic (TN) liquid crystals having a twist angle of  $90^\circ$  has been described in the foregoing by way of example, however, TN liquid crystals having a twist angle of less than  $90^\circ$ , supertwisted nematic (STN) liquid crystals having a twist angle in the range from  $180^\circ$  to  $270^\circ$ , or guest host liquid crystals and so forth may be used instead.

With the use of the supertwisted nematic liquid crystals, the transmission-voltage curve of the liquid crystal layer 3 can be made steeper, thereby increasing contrast.

When the liquid crystal layer 3 has a function of twisting the direction of linearly polarized light transmitted therethrough by the effect of phase modulation, the absorption-type polarizing film 14 and the reflection-type polarizing film 16, disposed on the opposite sides

of the liquid crystal cell 12, are arranged such that the transmission axes of both the films in parallel with each other, or cross each other at an angle equal to the twist angle of the liquid crystal layer 3 (at right angles if the twist angle is  $90^\circ$ ).

5           The guest host liquid crystals are mixed type liquid crystals made by dissolving a dichrotic dye as solute into liquid crystals as solvent. If the alignment condition of the guest host liquid crystal molecules is changed by applying an electric field thereto, the alignment of the dichrotic dye can be controlled following movement  
10 of the liquid crystal molecules, indicating display by modulating absorption of light incoming from a given direction.

By sealing the guest host liquid crystals in the liquid crystal cell 12 of the liquid crystal display panel 10, it is possible to show the regions for displaying information such as characters in a colored  
15 display condition in a metallic tone, and also to indicate colored display of the background part.

In this case, it is possible to create freely a combination of colors in which the regions for characters and the region for the background are displayed, respectively, by selecting the specified  
20 wavelength of a light component passing through the color filter 18, and the wavelengths of light components absorbed by the dichrotic dye dissolved in the guest host liquid crystals, respectively.

A case where the selective transmission color filter is used for the color filter 18 has been described in the foregoing by way of  
25 example, however, a dielectric multi layer film may be used instead.

The dielectric multi layer film is made by laminating a plurality of dielectrics having different refractive indices, and which

reflect a light component of incoming light at a specified wavelength while transmitting light components at other wavelengths.

Accordingly, if a color filter 18 made up of the dielectric multi layer film is disposed on the visible side of the absorption-type polarizing film 14, a light component of light falling on the liquid crystal display panel, at a specified wavelength only, is reflected by the color filter 18 made up of the dielectric multi layer film while light components at wavelengths other than the specified wavelength fall on the absorption-type polarizing film 14. Linearly polarized light having the polarized direction parallel with the transmission axis of the absorption-type polarizing film 14 then falls on the liquid crystal cell 12. In the background part behind the display parts, the linearly polarized light composed of the light components at wavelengths other than the specified wavelength undergoes phase modulation by  $90^\circ$  in the liquid crystal cell 12, and is also transmitted through the reflection-type polarizing film 16. On the other hand, in the display parts for characters and so forth, the linearly polarized light composed of the light components at wavelengths other than the specified wavelength is transmitted through the liquid crystal cell 12 without undergoing phase modulation as a voltage is applied between the electrodes of the liquid crystal cell 12, and undergoes specular reflection by the reflection-type polarizing film 16, being sent back to the visible side.

Therefore, in display regions for information such as characters, substantially all incoming light components are reflected, indicating bright display in a metallic tone. Meanwhile, in the background part behind the display regions, the background is seen colored, as a light

component at a specified wavelength only is reflected by the color filter 18 made up of the dielectric multi layer film, so that bright display in a metallic tone can be seen against the colored background.

With the use of the dielectric multi layer film, there will be  
5 little loss in the amount of light because of the makeup thereof. Also, it is possible to set freely the specified wavelength of a light component to be reflected by changing combinations of refractive indices of respective dielectric layers.

Further, a color polarizing film may be substituted for the color  
10 filter 18, and such an embodiment will be described in detail hereinafter.

Otherwise, a reflective color filter capable of transmitting a light component at a specified wavelength only, and reflecting light components at other wavelengths, a fluorescent filter having a  
15 function of converting the wavelength of incoming light, or so forth may be used instead.

## Second Embodiment

Next, a second embodiment of a liquid crystal display device  
20 according to the invention is described with reference to Fig 11.

Fig. 11 is a schematic sectional view illustrating the construction of a liquid crystal display panel serving as the liquid crystal display device. Parts corresponding to those previously described with reference to Figs. 1 to 10 are denoted by the same  
25 reference numerals, and description thereof is omitted.

The construction of the liquid crystal display panel is the same as that shown in Fig. 1 except that a light absorption film 13 is

disposed on the side (the underside in the figure) of the reflection-type polarizing film 16 opposite from the visible side. A light absorption film colored in black, an absorption-type polarizing film, an absorption-type color filter, or the like may be used for the light film  
5 13. In the case of using the absorption-type polarizing film, same is disposed such that the transmission axis thereof crosses that of the reflection-type polarizing film 16 at a right angle.

If the light absorption film 13 is disposed on the side of the reflection-type polarizing film 16, opposite from the visible side, light  
10 transmitted through the reflection-type polarizing film 16 can be absorbed by the light absorption film 13, so that the background part can be shown in a black or dark display condition for displaying information, indicating clearly colored display of characters and so forth in a metallic tone against the background.

As a result, contrast in display is improved. When display is  
15 inverted, various information such as time information and calendar information can be displayed with characters shown in black or in a color similar thereto in good contrast to the background shown in a bright and metallic tone.

In respect of other functions and application of various  
20 modifications, this embodiment is similar to the first embodiment, and therefore, description thereof is omitted.

### Third Embodiment

Now, a third embodiment of a liquid crystal display device  
25 according to the invention is described with reference to Fig. 12.

Fig. 12 is a schematic sectional view illustrating the



description thereof is therefore omitted.

#### Fourth Embodiment

Now, a fourth embodiment of a liquid crystal display device  
5 according to the invention is described with reference to Fig 13.  
Fig. 13 is a schematic sectional view illustrating the construction of a  
liquid crystal display panel serving as the liquid crystal display.  
Parts corresponding to those previously described with reference to  
Figs. 1 to 12 are denoted by the same reference numerals, and  
10 description thereof is omitted.

The construction of the liquid crystal display panel is the same  
as that shown in Fig. 1 except that a light absorption film 13 is  
disposed on the side of the reflection-type polarizing film 16, opposite  
from the visible side, and a light scattering film 15 is disposed on the  
15 visible side of the absorption-type polarizing film 14.

The liquid crystal display panel according to this embodiment  
has a construction wherein both the light absorption film 13 of the  
liquid crystal display panel shown in Fig. 11, and the light scattering  
film 15 of the liquid crystal display panel shown in Fig. 12 are  
20 installed, and consequently is able to have the operation and beneficial  
effects of both the films.

That is, with the use of the liquid crystal display panel, contrast  
between character parts thereof and the background part for displaying  
information can be enhanced, and a metallic tone in which colored  
25 display is indicated can be turned to a more delicate tone, allowing the  
display to be seen with more ease while widening a viewing angle as  
well.

In respect of other functions and application of various modifications, this embodiment is similar to the first embodiment, and description thereof is therefore omitted.

## 5 Fifth Embodiment

Now, a fifth embodiment of a liquid crystal display device according to the invention is described with reference to Fig 14. Fig. 14 is a schematic sectional view illustrating the construction of a liquid crystal display panel serving as the liquid crystal display.  
10 Parts corresponding to those previously described with reference to Figs. 1 to 10 are denoted by the same reference numerals, and description thereof is omitted.

The construction of the liquid crystal display panel is the same as that shown in Fig. 1 except that a backlight 17 is disposed on the  
15 side (the underside in the figure) of the reflection-type polarizing film 16, opposite from the visible side.

An electroluminescence device, a light-emitting diode (LED) array, or a light source such as a cold cathode tube or a hot cathode tube is used for the backlight 17.

20 If the backlight 17 is disposed on the side of the reflection-type polarizing film 16 opposite from the visible side, a half of light emitted from the backlight 17 and falling on the reflection-type polarizing film 16 is transmitted therethrough, and turned to the linearly polarized light, falling on the liquid crystal cell 12. In the  
25 background part, the linearly polarized light undergoes phase modulation by  $90^\circ$  when passing through the liquid crystal cell 12, and colored by the color filter 18 transmitting a light component at a



specified wavelength only, thereby being sent out to the visible side after being transmitted through the absorption-type polarizing film 14.

In character parts for displaying various information such as time information and calendar information, the light linearly polarized  
5 turned from light emitted by the backlight, and falling on the liquid crystal cell 12 does not undergo phase modulation by the liquid crystal layer 3 as a voltage is applied between the electrodes of the liquid crystal cell 12, and has therefore the polarized direction orthogonal to the transmission axis of the absorption-type polarizing  
10 film 14, thus being absorbed by the absorption-type polarizing film 14.

Consequently, even at dark places where no or little external light is available, various information such as time information and calendar information can be displayed in black or in a dark color  
15 against the bright background by the effect of colored light transmitted by lighting up the backlight 17.

In respect of other functions and application of various modifications, this embodiment is similar to the first embodiment, and description of these aspects is therefore omitted.

20

#### Sixth Embodiment

Now, a sixth embodiment of a liquid crystal display device according to the invention is described with reference to Fig 15.

Fig. 15 is a schematic sectional view illustrating the  
25 construction of a liquid crystal display panel serving as the liquid crystal display device. Parts corresponding to those previously described with reference to Figs. 1 to 14 are denoted by the same

reference numerals, and description thereof is omitted.

The construction of the liquid crystal display panel is the same as that shown in Fig. 14 except that a translucent film 19 is disposed between the reflection-type polarizing film 16 and the backlight 17.

5 In this embodiment of the invention, an absorption-type polarizing film is adopted for the translucent film 19, and disposed such that the transmission axis thereof intersects that of the reflection-type polarizing film 16 at an angle of 75°.

10 If the translucent film 19 is disposed between the reflection-type polarizing film 16 and the backlight 17, a half of light transmitted through the reflection-type polarizing film 16 can be absorbed by the translucent film 19 when the backlight 17 is not lit up, thereby darkening the background part, so that contrast of displayed information can be enhanced.

15 On the other hand, when the backlight 17 is lit up at places where ambient external light is insufficient, the background part can be made brighter by light transmitted through the translucent film 19, and characters and so forth for displaying information can be indicated in black and darker display.

20 Consequently, whether the backlight 17 is lit up or not, contrast of display can be enhanced.

In respect of other functions and application of various modifications, this embodiment is similar to the first embodiment and the fifth embodiment, and description of these aspects is therefore  
25 omitted.

#### Seventh Embodiment

Now, a seventh embodiment of a liquid crystal display device according to the invention is described with reference to Fig. 16. Fig. 16 is a schematic sectional view illustrating the construction of a liquid crystal display panel serving as the liquid crystal display device.

5 Parts corresponding to those previously described with reference to Figs. 1 to 14 are denoted by the same reference numerals, and description thereof is omitted.

The construction of the liquid crystal display panel is the same as that shown in Fig. 14 except that a light scattering film 15 is

10 disposed on the visible side of the absorption-type polarizing film 14.

By installing the light scattering film 15 on the visible side of the absorption-type polarizing film 14, it is possible to cause light outgoing to the visible side after specular reflection by the absorption-type polarizing film 14 to undergo irregular reflection

15 by the agency of the light scattering film 15. As a result, a colored metallic tone in which characters and so forth expressing information are displayed can be turned to a more delicate tone, causing the display to be seen with more ease while widening a viewing angle as well.

20 In respect of other functions and application of various modifications, this embodiment is similar to the first embodiment and the fifth embodiment, and description of these aspects is therefore omitted.

## 25 Eighth Embodiment

Now, an eighth embodiment of a liquid crystal display device according to the invention is described with reference to Fig 17. Fig.

17 is a schematic sectional view illustrating the construction of a liquid crystal display panel serving as the liquid crystal display device. Parts corresponding to those previously described with reference to Figs. 1 to 16 are denoted by the same reference numerals, and  
5 description thereof is omitted.

The construction of the liquid crystal display panel is the same as that shown in Fig. 15 except that a light scattering film 15 is disposed on the visible side of the absorption-type polarizing film 14.

By installing the light scattering film 15 on the visible side of  
10 the absorption-type polarizing film 14, it is possible to cause light outgoing to the visible side after specular reflection by the absorption-type polarizing film 14 to undergo irregular reflection by the agency of the light scattering film 15. As a result, a colored metallic tone in which characters and so forth expressing information  
15 are displayed can be turned to a more delicate tone, causing the display to be seen with more ease while widening a viewing angle as well.

In respect of other functions and application of various modifications, this embodiment is similar to the first embodiment and  
20 the sixth embodiment, and description of these aspects is therefore omitted.

### Ninth Embodiment

Now, a ninth embodiment of a liquid crystal display device  
25 according to the invention is described with reference to Figs. 18 and 19. Figs. 18 and 19 are schematic sectional views illustrating the construction of a liquid crystal display panel serving as the liquid

crystal display device, and the principles of colored display thereby. Parts corresponding to those previously described with reference to Figs. 1 to 11 are denoted by the same reference numerals, and description thereof is omitted. In Figs. 18 and 19, the direction of stripes on respective polarizing films and significance of respective solid lines with an arrow or arrows are same as described with reference to Figs. 9 and 10.

The construction of the liquid crystal display panel is the same as that shown in Fig. 11 except that a color polarizing film 28 serving as a color filter is disposed between the absorption-type polarizing film 14 and the liquid crystal cell 12 in place of the selective transmission color filter 18.

The color polarizing film 28 is capable of transmitting a light component of linearly polarized light in the direction orthogonal to the transmission axis of the color polarizing film 28, at a specified wavelength only, and absorbing light components of the linearly polarized light, at other wavelengths. However, the color polarizing film 28 has an optical property of transmitting both a light component of linearly polarized light in the direction parallel with the transmission axis thereof, at a specified wavelength, and light components of the linearly polarized light at other wavelengths.

In this case, the color polarizing film 28 is disposed such that the transmission axis thereof crosses that of the absorption-type polarizing film 14 at a right angle.

In this embodiment of the invention, the absorption-type polarizing film 14, the color polarizing film 28, and the liquid crystal cell 12 are disposed in this order.

Accordingly, since light transmitted through the absorption-type polarizing film 14 is the light linearly polarized in the direction orthogonal to the transmission axis of the color polarizing film 28, a light component thereof, at a specified wavelength only, is transmitted  
5 through the color polarizing film 28. However, light components of the linearly polarized light transmitted through the absorption-type polarizing film 14 at other wavelengths are absorbed by the color polarizing film 28. In the case of the example shown in the figures, the specified wavelength is that of a light component in yellow.

10 Fig. 18 shows the optical path of light components falling from the visible side onto the liquid crystal display panel, other than the light component in yellow, and Fig. 19 shows the optical path of the light component in yellow. The left half part of the figures indicates an OFF state where no voltage is applied between the  
15 electrodes of the liquid crystal cell 12, and the right half part thereof indicates an ON state where a voltage is applied between the electrodes of the liquid crystal cell 12.

As shown in Fig. 18, the light components falling from the visible side onto the liquid crystal display panel, other than the light  
20 component in yellow, are transmitted through the absorption-type polarizing film 14 and turned to linearly polarized light in the direction parallel with the transmission axis of the absorption-type polarizing film 14 (parallel with the plane of the figure), then falling on the color polarizing film 28. Since the direction of the oscillation  
25 plane thereof crosses the transmission axis of the color polarizing film 28 at a right angle, all the light components described above are absorbed by the color polarizing film 28, thus making no contribution

to display regardless of whether the liquid crystal cell 12 is in the ON state or the OFF state.

As shown in Fig. 19, the light component in yellow falling from the visible side onto the liquid crystal display panel is transmitted through the absorption-type polarizing film 14 and turned to linearly polarized light in the direction parallel with the transmission axis of the absorption-type polarizing film 14, then falls on the color polarizing film 28 as with the case of the light components other than the light component in yellow. However, although the direction of polarization thereof is orthogonal to the transmission axis of the color polarizing film 28, linearly polarized light in yellow can be transmitted through the color polarizing film 28, and falls unaltered on the liquid crystal cell 12.

In the background part where the liquid crystal cell 12 is in the OFF state, the linearly polarized light in yellow falling on the liquid crystal cell 12 undergoes phase modulation by  $90^\circ$  when transmitted through the liquid crystal cell 12, and the direction of the polarization thereof is caused to turn parallel with (perpendicular to the plane of the figure) the transmission axis of the reflection-type polarizing film 16. As a result, the linearly polarized light in yellow is transmitted through the reflection-type polarizing film 16, and absorbed by the light absorption film 13 disposed behind the reflection-type polarizing film 16. From the visible side, therefore, display is seen in a black or darker tone.

On the other hand, in display parts for characters and so forth, where the liquid crystal cell 12 is in the ON state, the linearly polarized light in yellow falling unaltered on the liquid crystal cell 12

is transmitted therethrough, without undergoing phase modulation, and falls on the reflection-type polarizing film 16. Consequently, the linearly polarized light in yellow in the direction orthogonal to the transmission axis of the reflection-type polarizing film 16 undergoes  
5 specular reflection by the reflection-type polarizing film 16, outgoing to the visible side along the optical path thereof in the reverse direction.

It follows that in regions for characters and so forth for displaying information, substantially all the light component in yellow,  
10 falling on the liquid crystal cell 12, is reflected, indicating bright display in a colored (yellow) and metallic tone against the background part in a black or darker tone.

Consequently, in marked contrast to conventional electronic equipment for displaying various information such as time  
15 information and calendar information in black against the background in white, the liquid crystal display panel, even if used as a display device of electronic equipment, will be able to have variation in design, and be a lot of fun to use.

By selecting a specified wavelength (that is, a color) of a light  
20 component to be transmitted through the color polarizing film 28, display in a metallic tone can be executed in various colors.

#### Tenth Embodiment

Now, a tenth embodiment of a liquid crystal display device  
25 according to the invention is described with reference to Figs. 20 and 21. Figs. 20 and 21 are schematic sectional views illustrating the construction of a liquid crystal display panel serving as the liquid



crystal display device and the principles of colored display thereby. Parts corresponding to those previously described with reference to Figs. 1 to 11 are denoted by the same reference numerals, and description thereof is omitted. In Figs. 20 and 21, the direction of stripes on respective polarizing films and significance of respective solid lines with an arrow or arrows are same as described with reference to Figs. 9 and 10.

The construction of the liquid crystal display panel is the same as that shown in Figs. 18 and 19 except that a color polarizing film 28 serving as a color filter is disposed between the liquid crystal cell 12 and the reflection-type polarizing film 16.

The color polarizing film 28 according to this embodiment as well is capable of transmitting a component of linearly polarized light in the direction orthogonal to the transmission axis thereof, at a specified wavelength (in yellow, in this case) only, and absorbing light components of the linearly polarized light at other wavelengths (in colors other than yellow).

As shown in Figs. 20 and 21, all light components falling from the visible side onto the liquid crystal display panel are transmitted through the absorption-type polarizing film 14, and turned to linearly polarized light in the direction parallel with the transmission axis of the absorption-type polarizing film 14 (parallel with the plane of the figure), then falling on the liquid crystal cell 12. The linearly polarized light undergoes phase modulation by  $90^\circ$  in the left half part of the figures, where the liquid crystal cell 12 is in an OFF state, when transmitted through the liquid crystal cell 12, and turned to linearly polarized light in the direction parallel with the transmission axis of

the color polarizing film 28, falling then on the color polarizing film 28.

Accordingly, in the background part where the liquid crystal cell 12 is in the OFF state, both the light component in yellow and the light components in colors other than yellow are transmitted through the color polarizing film 28 as well as the reflection-type polarizing film 16 disposed such that the transmission axis thereof is parallel with that of the color polarizing film 28, and are absorbed by the light absorption film 13 as shown in Figs. 20 and 21.

In display regions for characters and so forth, where the liquid crystal cell 12 is in an ON state, the light components in colors other than yellow are absorbed by the color polarizing film 28 as shown in Fig. 20. However, the light component in yellow is transmitted through the color polarizing film 28, and falls on the reflection-type polarizing film 16, whereupon the light component in yellow undergoes mirror reflection, by the reflection-type polarizing film 16 because the direction of linear polarization thereof crosses the transmission axis of the reflection-type polarizing film 16 at a right angle, outgoing to the visible side along the optical path thereof in the reverse direction. Consequently, substantially all the colored light component after falling on the liquid crystal cell 12 will be reflected, outgoing to the visible side.

It follows therefore that the use of the liquid crystal display panel can also provide bright display of various information such as time information and calendar information in a colored and metallic tone against the background seen in a black or darker tone.

Consequently, in marked contrast to conventional electronic

equipment for displaying various information such as time  
information and calendar information in black against the background  
in white, the liquid crystal display panel used as a display device of  
electronic equipment will be able to have variation in design, and be a  
5 lot of fun to use.

Furthermore, by selecting a specified wavelength (that is, a  
color) of a light component to be transmitted through the color  
polarizing film 28, display in a metallic tone can be executed in  
various colors.

10 With the ninth and the tenth embodiment of the liquid crystal  
display panel according to the invention, as described in the foregoing,  
the color polarizing film 28 may be disposed on the visible side of the  
absorption-type polarizing film 14, or on the inner surface side of  
either of the electrodes inside the liquid crystal cell 12 as with the  
15 case of the color filter 18 described in connection with the first  
embodiment.

Furthermore, various alternatives to the color filter 18, as  
described in connection with the first embodiment, are also applicable  
to the ninth and the tenth embodiment of the liquid crystal display  
20 panel described above.

## INDUSTRIAL APPLICABILITY

As is evident from the foregoing description, with the liquid  
crystal display device according to the invention, display of various  
25 information can be indicated in a bright relief in a colored metallic  
tone against a dark background, or conversely, the display can be  
indicated in a black or dark color against a background shown in a

colored metallic tone, thus enabling suitable selection of a color in which the display is to be indicated.

Thus, in marked contrast to conventional timepieces or other electronic equipment for displaying information such as time  
5 information and calendar information in black against the background in white, the use of the liquid crystal display device (liquid crystal display panel) as a display panel of various electronic equipment can provide display of colorful variation in design, and offering some fun of use.

10 Further, the liquid crystal display device according to the invention are applicable to a liquid crystal display device with a backlight, which can be put to use at dark places where little or no external light is available.

The scope of the invention is not limited to a liquid crystal  
15 display device for digitally displaying time information and calendar information or numerical information by use of numbers, but includes a liquid crystal display device wherein a liquid crystal display panel of the dot-matrix display mode is adopted for the liquid crystal display panel described above to display arbitrary characters or graphics, or  
20 an electrode of a liquid crystal cell is formed to be a number of graphic patterns which are displayed selectively.

What is claimed is:

1. A liquid crystal display comprising:

5 a liquid crystal cell having a liquid crystal layer sealed in between a pair of transparent substrates thereof, having an electrode on each of the inner surfaces thereof, facing each other;

an absorption-type polarizing film disposed on the visible side of the liquid crystal cell, for absorbing the light linearly polarized in the direction orthogonal to the transmission axis thereof;

10 a reflection-type polarizing film disposed on the side of the liquid crystal cell, opposite from the visible side thereof, for reflecting the light linearly polarized in the direction orthogonal to the transmission axis thereof; and

15 a color filter disposed on the visible side of the absorption-type polarizing film, or between the absorption-type polarizing film and the reflection-type polarizing film.

2. The liquid crystal display device according to Claim 1 further comprising a light absorption film disposed on the side of said reflection-type polarizing film, opposite from the visible side thereof.

20 3. The liquid crystal display device according to Claim 1 further comprising a light scattering film disposed on the visible side of said absorption-type polarizing film.

25 4. The liquid crystal display device according to Claim 1 further comprising a light scattering film disposed on the visible side of said absorption-type polarizing film, and a light absorption film disposed on the side of said reflection-type polarizing film, opposite from the visible side thereof.

5. The liquid crystal display device according to Claim 1 further comprising a backlight disposed on the side of said reflection-type polarizing film, opposite from the visible side thereof.

6. The liquid crystal display device according to Claim 5 further comprising a translucent film disposed between said reflection-type polarizing film and the backlight.

7. The liquid crystal display according to Claim 6, wherein the translucent film is an absorption-type polarizing film.

8. The liquid crystal display according to Claim 1 further comprising a light scattering film disposed on the visible side of said absorption-type polarizing film, and a backlight disposed on the side of said reflection-type polarizing film, opposite from the visible side thereof.

9. The liquid crystal display according to Claim 8 further comprising a translucent film disposed between said reflection-type polarizing film and the backlight.

10. The liquid crystal display according to Claim 9, wherein the translucent film is an absorption-type polarizing film.

11. The liquid crystal display as in any one of Claims 1 to 10, wherein said absorption-type polarizing film is disposed on the visible side of said liquid crystal cell such that the transmission axis of said absorption-type polarizing film is parallel with the direction of the long axes of liquid crystal molecules located on the visible side of the liquid crystal layer in said liquid crystal cell while said reflection-type polarizing film is disposed such that the transmission axis thereof is parallel with, or orthogonal to the direction of the long axes of liquid crystal molecules located on the side of the liquid crystal layer

in said liquid crystal cell, opposite from the visible side thereof.

12. The liquid crystal display device as in any one of Claims 1 to 10,

5 wherein said absorption-type polarizing film is disposed on the visible side of said liquid crystal cell such that the transmission axis of said absorption-type polarizing film is orthogonal to the direction of the long axes of liquid crystal molecules located on the visible side of the liquid crystal layer in said liquid crystal cell while said reflection-type polarizing film is disposed such that the transmission  
10 axis thereof is parallel with, or orthogonal to the direction of the long axes of liquid crystal molecules located on the side of the liquid crystal layer in said liquid crystal cell, opposite from the visible side thereof.

13. The liquid crystal display as in any one of Claims 1 to 12,  
15 wherein said color filter is a selective transmission color filter for transmitting a light component at a specified wavelength only.

14. The liquid crystal display according to Claim 13,  
wherein said color filter comprises color filters in plural colors at different specified wavelengths which are arranged in the same  
20 plane.

15. The liquid crystal display device according to Claim 13,  
wherein said color filter comprises color filters in three colors at specified wavelengths of light components in red, green and blue, arranged in a given order repeatedly and regularly.

25 16. The liquid crystal display device according to Claim 13,  
wherein said color filter comprises color filters in three colors at specified wavelengths of light components in cyan, magenta and

yellow, arranged in a given order repeatedly and regularly.

17. The liquid crystal display device as in any one of Claims 1 to 12,

wherein said color filter is a color polarizing film capable of transmitting a light component of the light linearly polarized in the direction orthogonal to the transmittable axis thereof and having a specified wavelength only, and absorbing light components of the light linearly polarized at other wavelengths while transmitting all light components of the light linearly polarized in the direction parallel with the transmission axis thereof.

18. The liquid crystal display device as in any one of Claims 1 to 12,

wherein said color filter is a multi-layered dielectric coating capable of reflecting a light component of incoming light, and having a specified wavelength, while transmission light components of the incoming light at other wavelengths.

19. The liquid crystal display device as in any one of Claims 1 to 18, wherein the liquid crystal layer of said liquid crystal cell is composed of any from among twisted nematic liquid crystals, supertwisted nematic liquid crystals, and guest host liquid crystals.

20. The liquid crystal display device as in any one of Claims 1 to 19, wherein said color filter is disposed between said absorption-type polarizing film and said liquid crystal cell.

21. The liquid crystal display device as in any one of Claims 1 to 19, wherein said color filter is disposed between said liquid crystal cell and said reflection-type polarizing film.



22. The liquid crystal display device as in any one of Claims 1 to 19, wherein said color filter is disposed between one of the transparent substrates making up said liquid crystal cell and the liquid crystal layer.

## ABSTRACT

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A liquid crystal display panel serving as a liquid crystal display device comprises a liquid crystal cell having a liquid crystal layer sealed in between a pair of transparent substrates, having an electrode on each of the inner surfaces thereof, facing each other, an absorption-type polarizing film disposed on the visible side of the liquid crystal cell, for absorbing the light linearly polarized in the direction orthogonal to the transmission axis thereof, a reflection-type polarizing film disposed on the side of the liquid crystal cell opposite from the visible side thereof for reflecting the light linearly polarized in the direction orthogonal to the transmission axis thereof, and a color filter disposed on the visible side of the absorption-type polarizing film, or between the absorption-type polarizing film and the reflection-type polarizing film.

FIG. 1

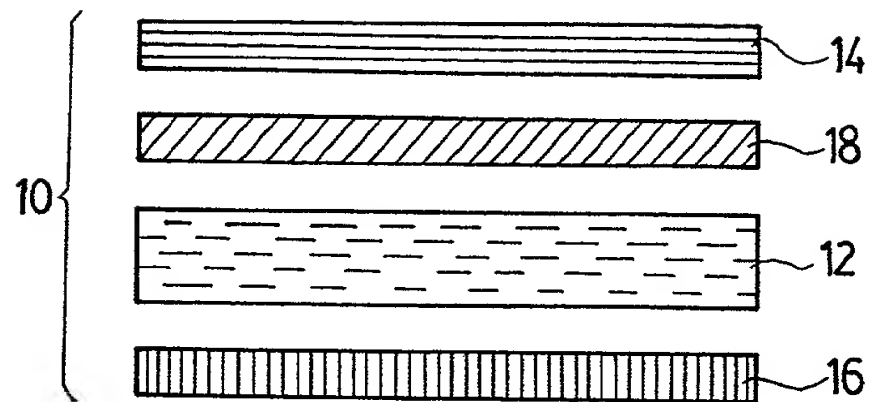


FIG. 2

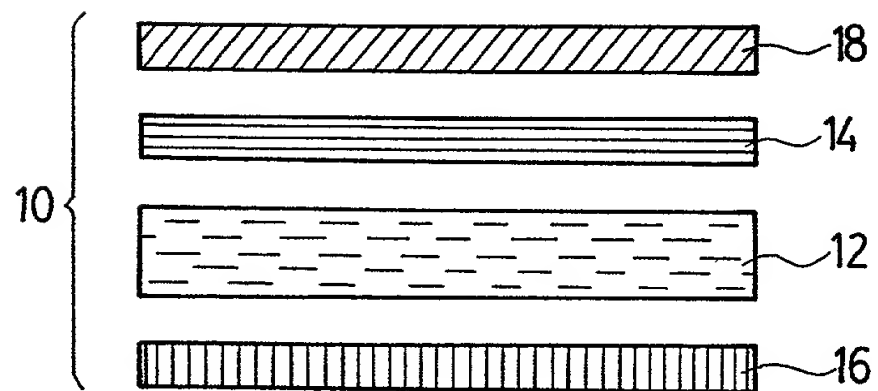


FIG. 3

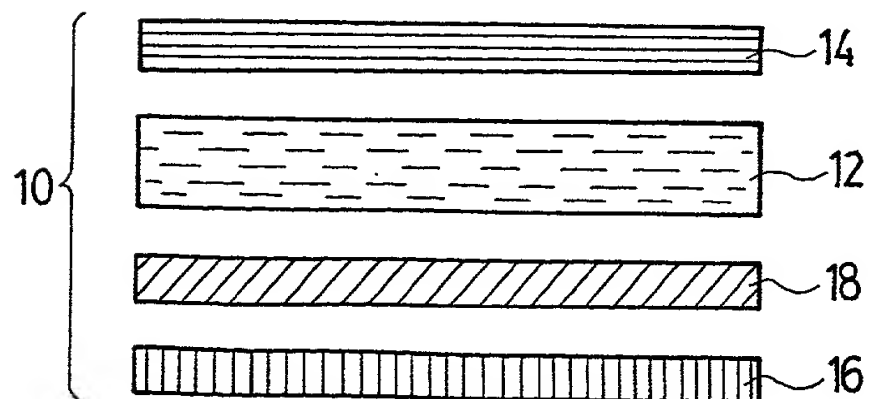


FIG. 4

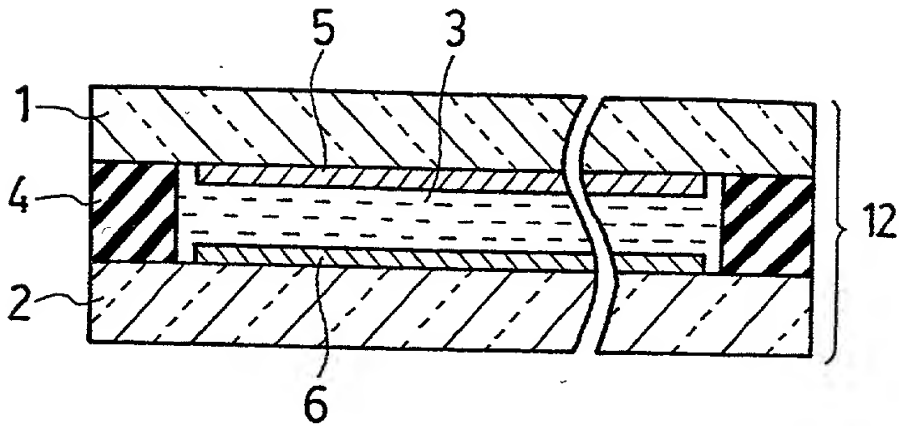


FIG. 5

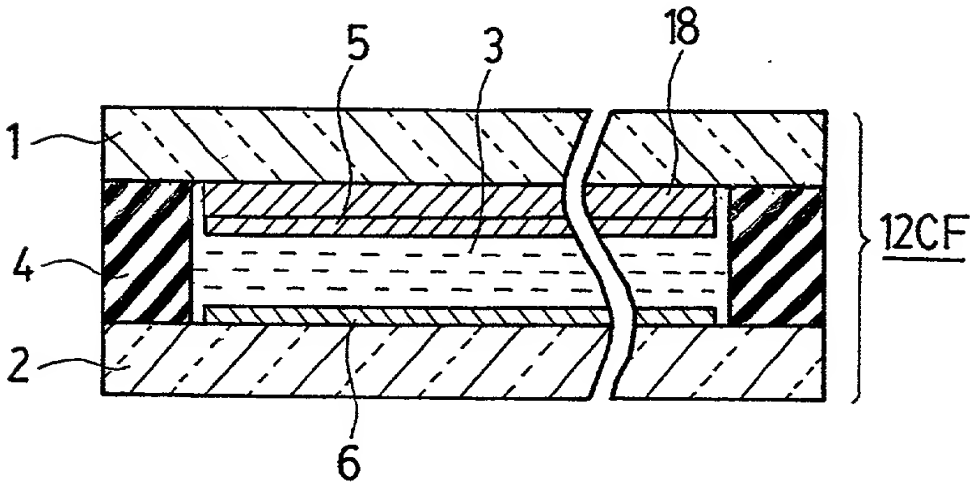
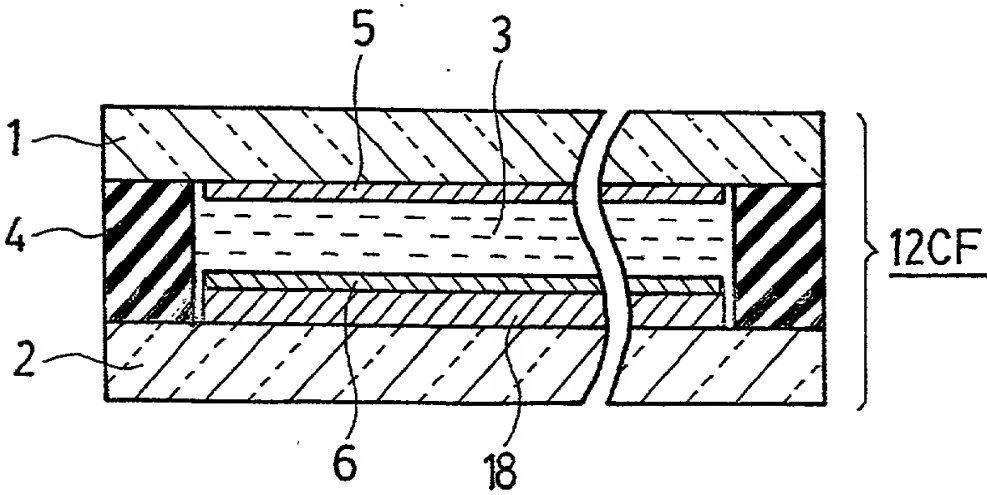


FIG. 6



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FIG. 7

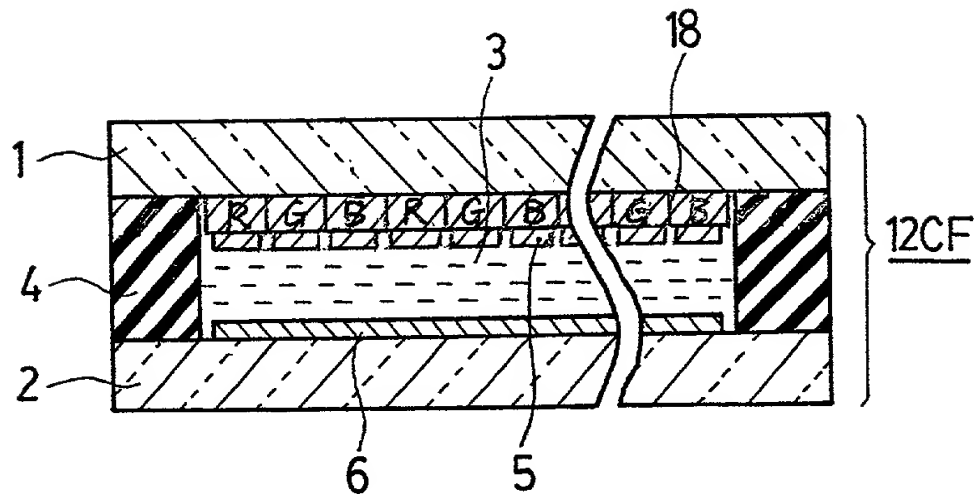


FIG. 8

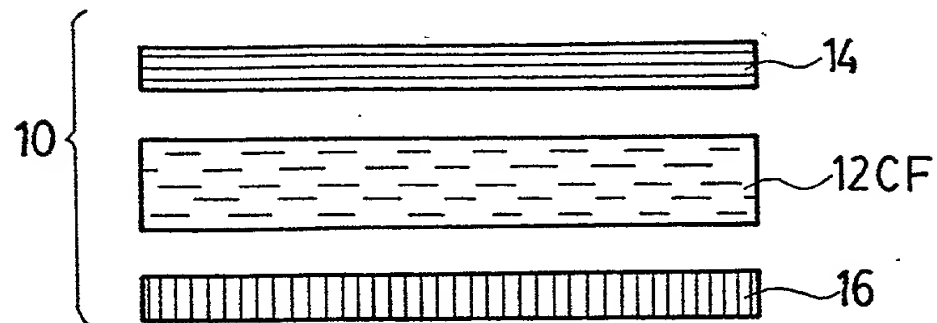
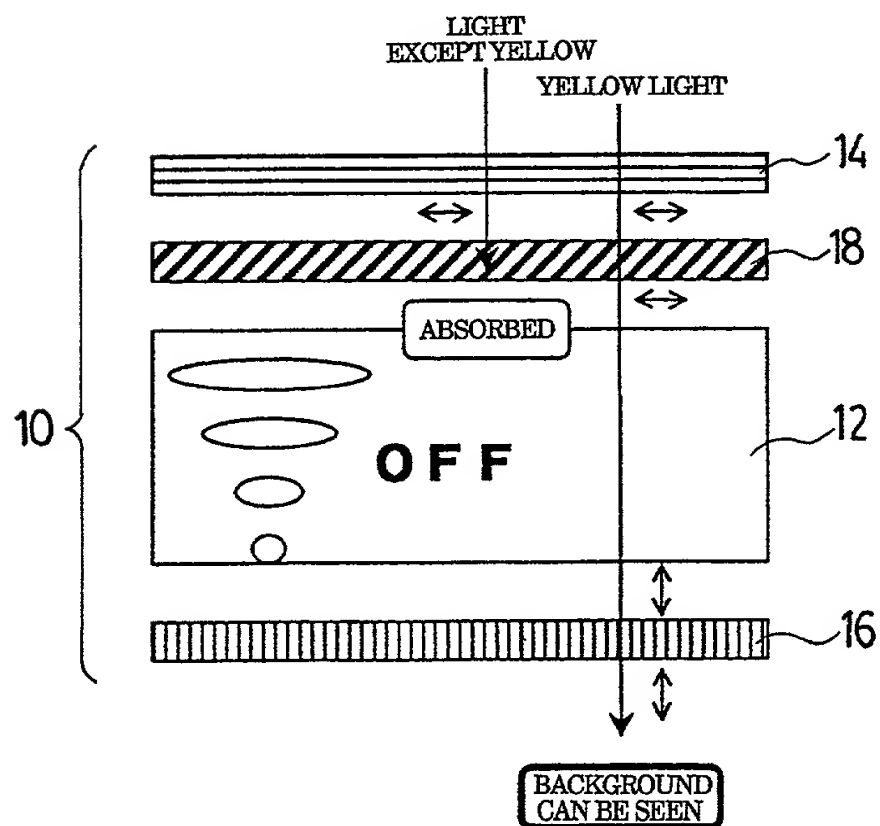


FIG. 9



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FIG. 10

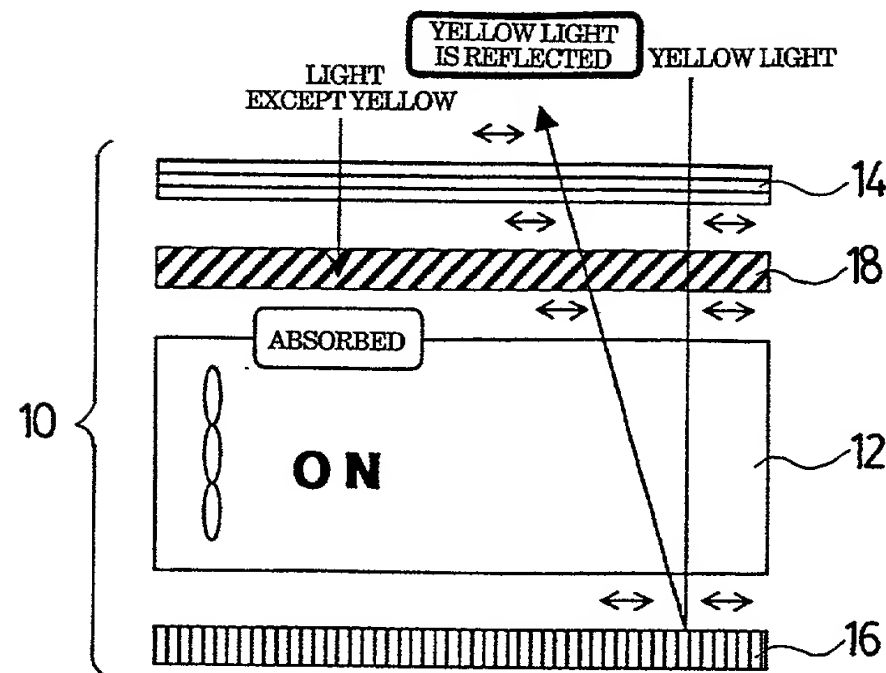


FIG. 11

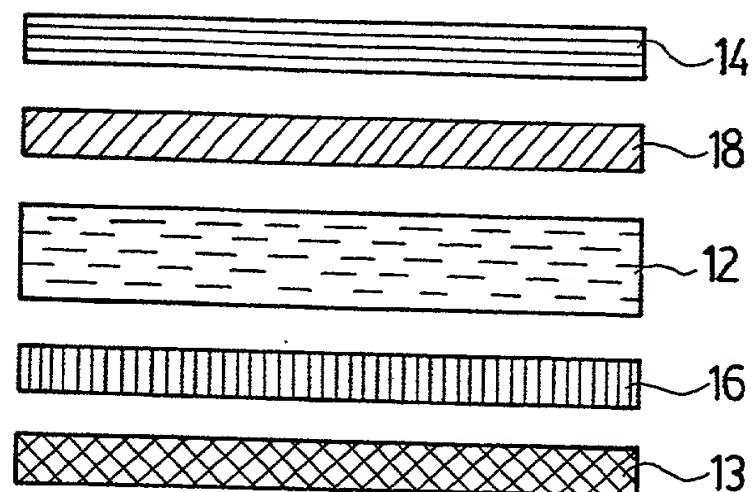


FIG. 12

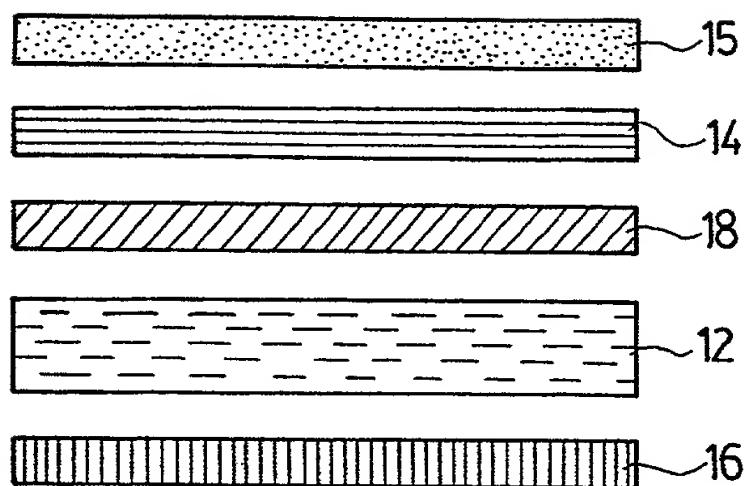


FIG. 13

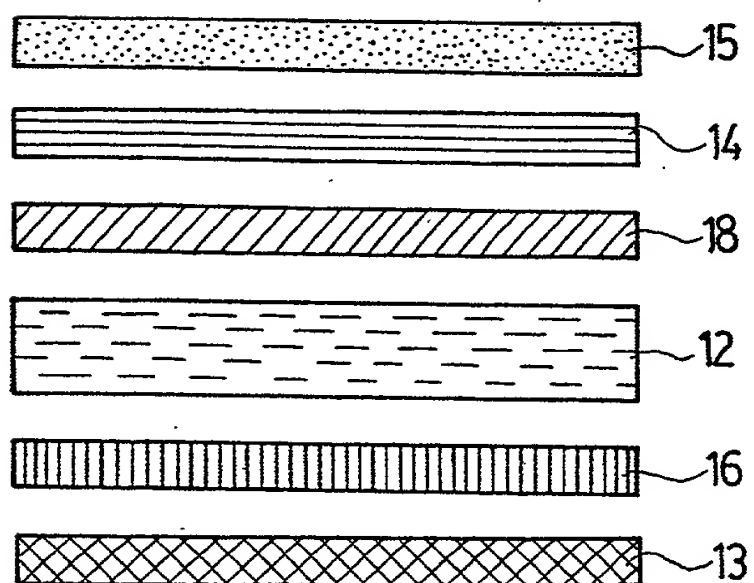


FIG. 14

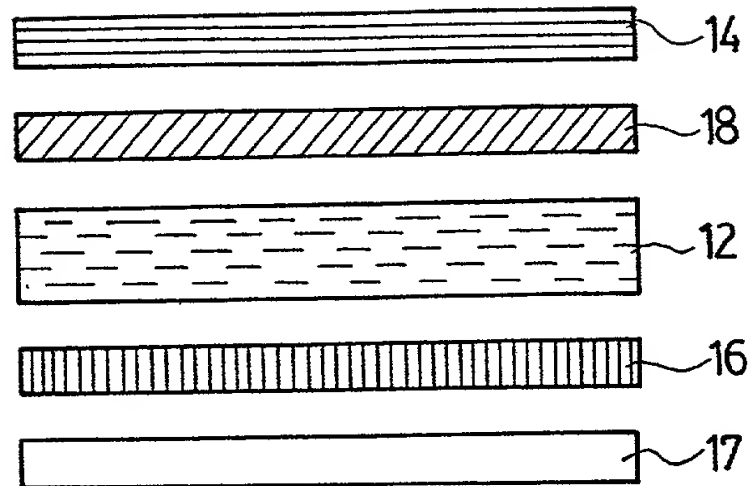


FIG. 15

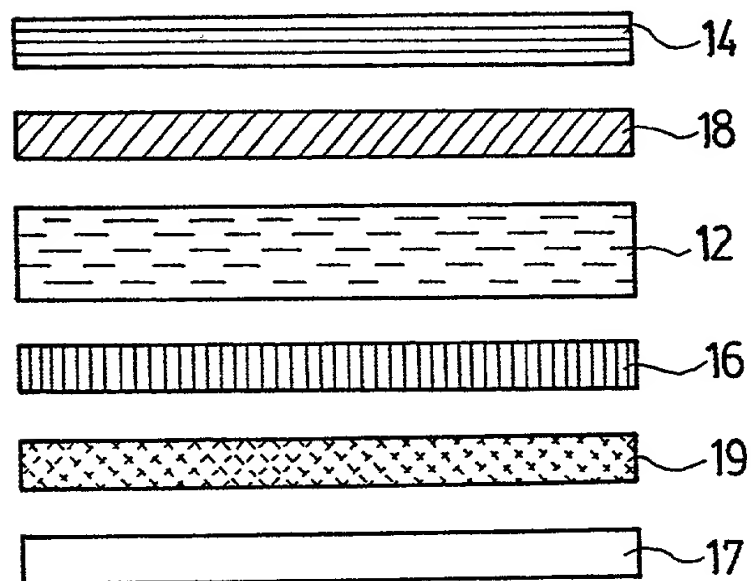




FIG. 16

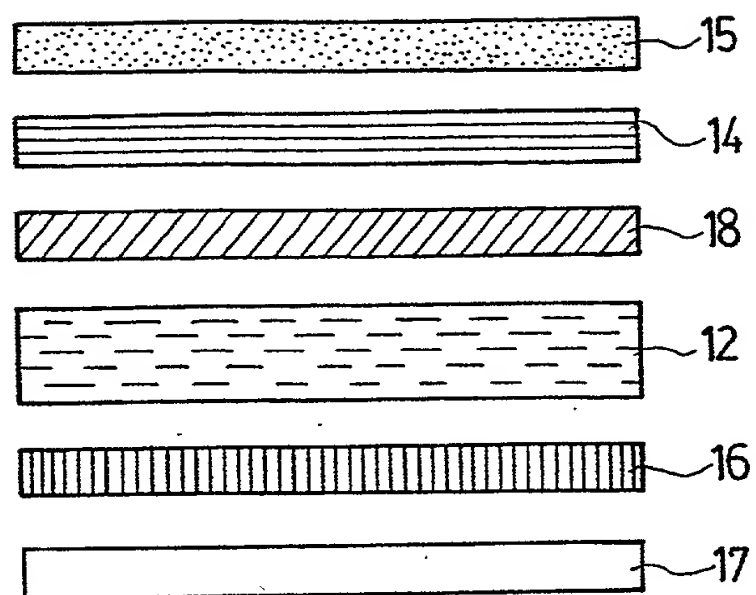


FIG. 17

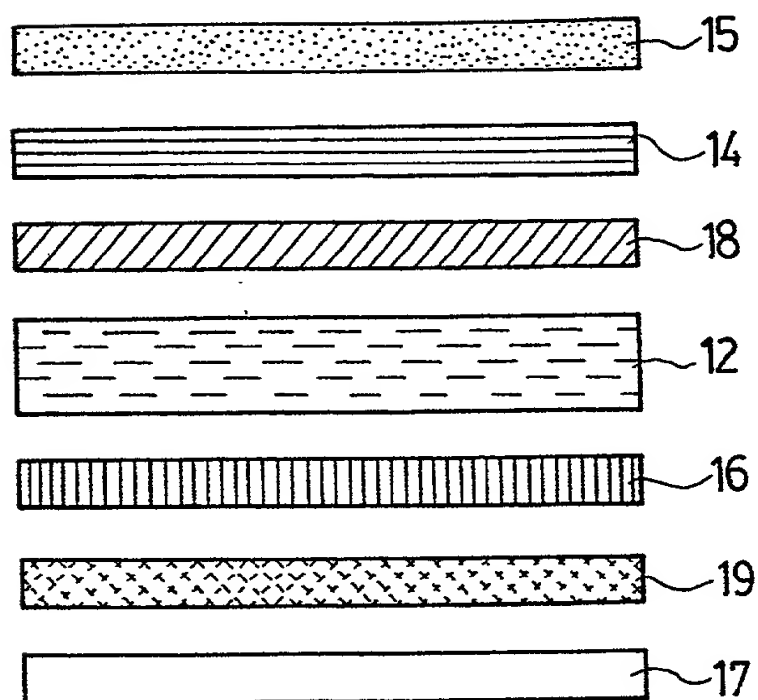


FIG. 18

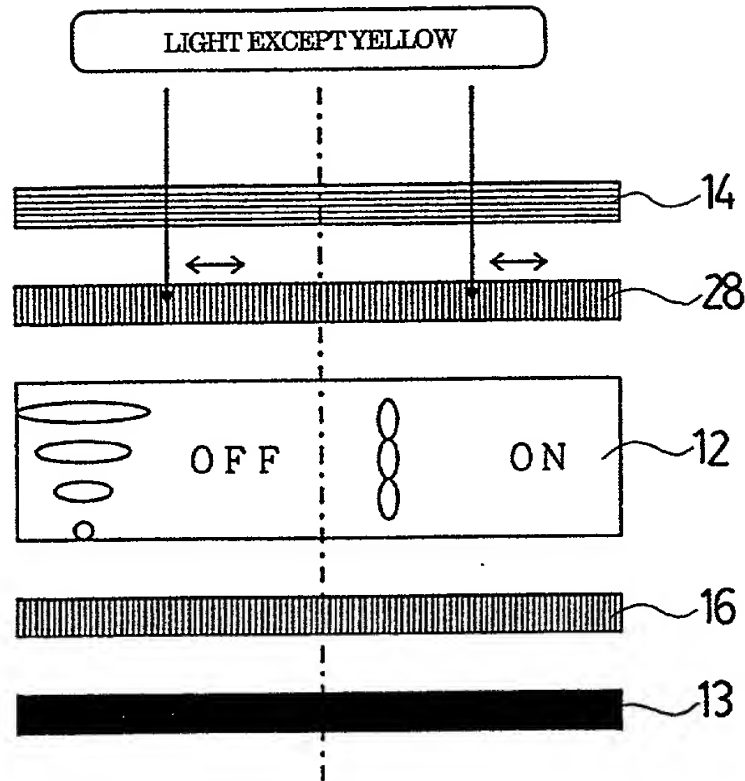


FIG. 19

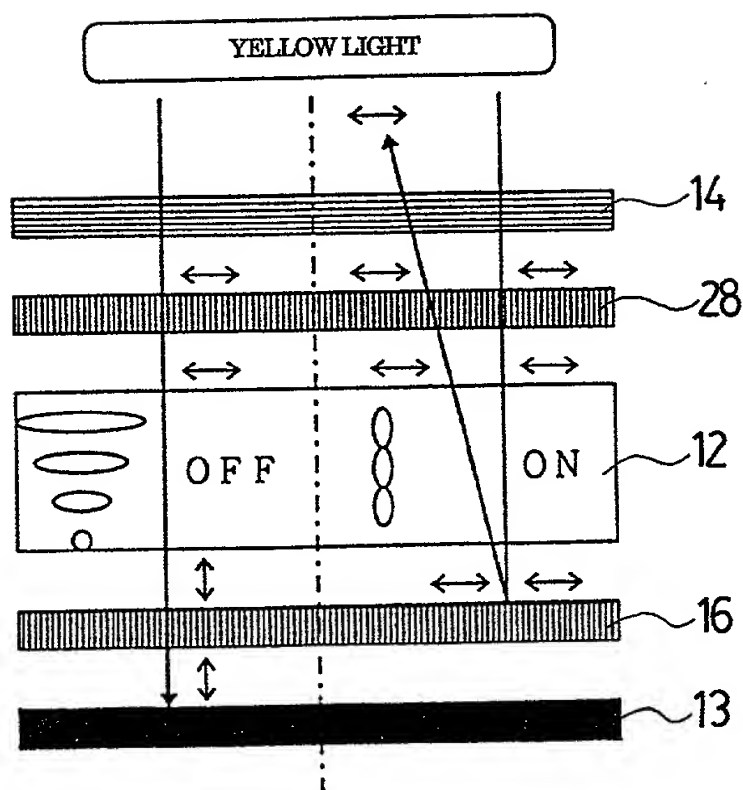


FIG. 20

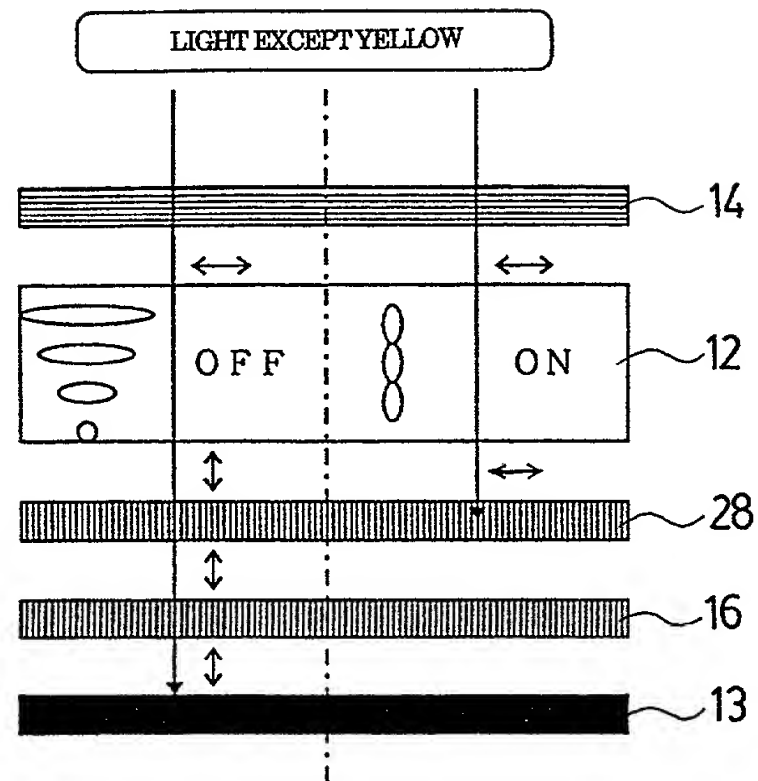
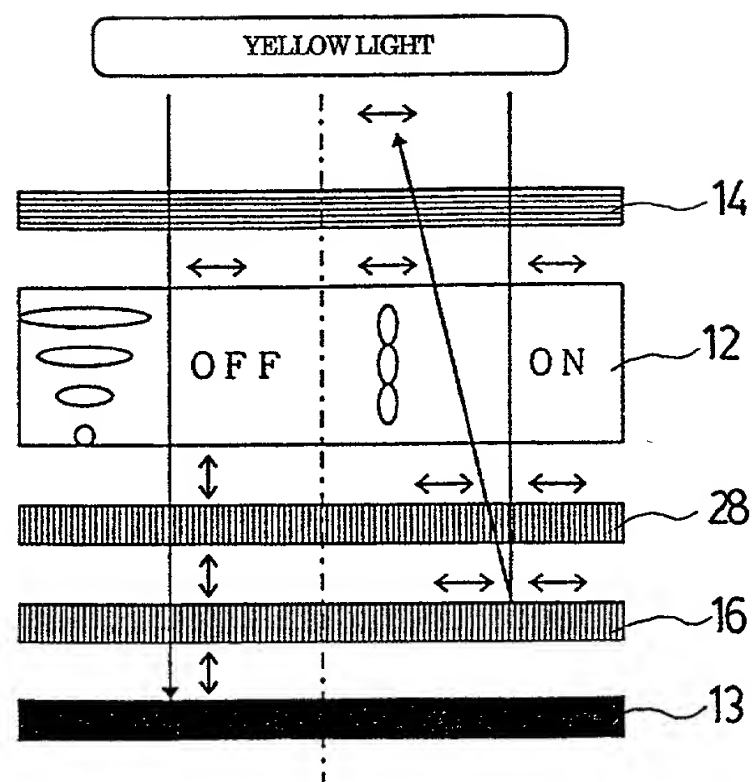


FIG. 21



# Declaration For U.S. Patent Application

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention **entitled**  
(Insert Title) LIQUID CRYSTAL DISPLAY DEVICE

the specification of which is attached hereto unless the following is checked:



was filed on July 30, 1998 as United States Application Number or PCT International  
Application Number PCT/JP98/03411 and was amended on \_\_\_\_\_  
(if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 (a) - (d) of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

(List prior foreign applications. See note A on back of this page)	Patent Appln. 9-204415	JAPAN	30/July/1997	Priority Claimed
	(Number)	(Country)	(Day/Month/Year Filed)	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
	_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	<input type="checkbox"/> Yes <input type="checkbox"/> No
	_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	<input type="checkbox"/> Yes <input type="checkbox"/> No
	_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	<input type="checkbox"/> Yes <input type="checkbox"/> No
	_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	<input type="checkbox"/> Yes <input type="checkbox"/> No

(See note B on back of this page)

☐ See attached list for additional prior foreign applications

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below.

_____ (Application Number)	_____ (Filing Date)
_____ (Application Number)	_____ (Filing Date)

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of the application:

(List Prior U.S. Applications)	(Application Serial Number)	(Filing Date)	(Status) (patented, pending, abandoned)
	_____ (Application Serial Number)	_____ (Filing Date)	_____ (Status) (patented, pending, abandoned)

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

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Washington, D.C. 20006

Telephone: (202) 659-2930 Fax: (202) 887-0357

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Title 18 of the United States Code, § 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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(See note 80 C above) Inventor's Signature Yuichi Akiba Date March 19, 1999

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Post Office Address c/o CITIZEN WATCH Co., Ltd., Technical Laboratory, 840, Aza-Takeno, Oaza-Shimotomi, Tokorozawa-shi, Saitama 359-8511, Japan

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Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_

Residence \_\_\_\_\_ Citizenship \_\_\_\_\_

Post Office Address \_\_\_\_\_

Full name of third inventor (given name, family name) \_\_\_\_\_

Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_

Residence \_\_\_\_\_ Citizenship \_\_\_\_\_

Post Office Address \_\_\_\_\_

Full name of fourth inventor (given name, family name) \_\_\_\_\_

Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_

Residence \_\_\_\_\_ Citizenship \_\_\_\_\_

Post Office Address \_\_\_\_\_

Full name of fifth inventor (given name, family name) \_\_\_\_\_

Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_

Residence \_\_\_\_\_ Citizenship \_\_\_\_\_

Post Office Address \_\_\_\_\_

Full name of sixth inventor (given name, family name) \_\_\_\_\_

Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_

Residence \_\_\_\_\_ Citizenship \_\_\_\_\_

Post Office Address \_\_\_\_\_

Full name of seventh inventor (given name, family name) \_\_\_\_\_

Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_

Residence \_\_\_\_\_ Citizenship \_\_\_\_\_

Post Office Address \_\_\_\_\_

Full name of eighth inventor (given name, family name) \_\_\_\_\_

Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_

Residence \_\_\_\_\_ Citizenship \_\_\_\_\_

Post Office Address \_\_\_\_\_